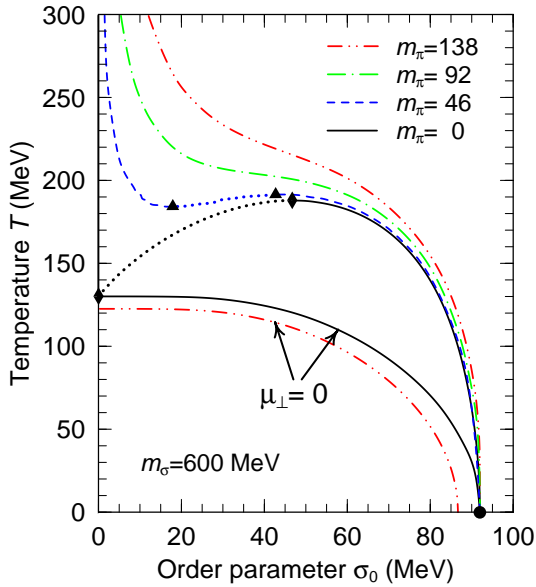


Phase structure of the semi-classical linear sigma model*

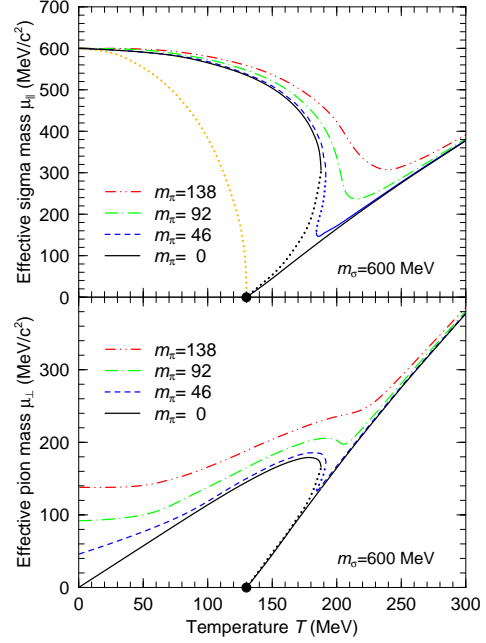
Jørgen Randrup

In the present work, we have studied the phase structure emerging with the semi-classical treatment of the simple linear σ model. Starting from the canonical partition function, we have obtained the statistical weight as a function of the magnitude and orientation of the chiral order parameter. This has enabled us to determine the phase diagram for any given size of the volume, Ω , and the free pion mass, m_π , as has been illustrated in the figures.



While the idealized scenario of vanishing pion mass and infinite volume yields a first-order phase transition, this structure is gradually being eroded as either the mass or the volume is changed to more realistic values, and it is ultimately being replaced by a smooth crossover.

It has been checked that the field equation of motion, with the semi-classical initialization of the field, in fact leads to dynamical evolutions in accordance with the phase structure derived from the analysis of the calculated partition function. Thus the results provide a good quantitative guide for what can be expected from dynamical simulations with this model.



The present treatment may be less reliable in idealized O(4) symmetric case ($m_\pi=0$), since a full quantal treatment is expected to yield a second-order transition, in the thermodynamic limit. Fortunately, this possible limitation has little bearing on the practical applications of the treatment to problems in high-energy collision dynamics, where the magnitude of the actual pion mass and the finite size of the systems both ensure a crossover behavior.

Furthermore, since the scenarios of interest are rapidly expanding, a complete mode decoupling occurs relatively quickly and thus prevents the approach to equilibrium from proceeding very far. Therefore it appears that the semi-classical model may in fact provide a physically reasonable treatment of the problem, within the overall limitations arising from the neglect of specific quantum-field effects and additional degrees of freedom, such as strangeness or baryons.

* From LBNL-46037: J. Heavy Ion Phys. (in press)